Review Article

Recent Trends in Forensic Odontology: An Overview

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Abstract

Every human being has unique identity in life. Forensic odontology is an emerging branch of science which has a greatest scope of development. The most challenging feature of forensic dentistry includes the identification of dental remains, recovery, and analysis of evidence which match with the suspects. An objective comparison using recent technology would strengthen the validity of evidence in forensic dentistry. It has been established as an irreplaceable science in medicolegal matters and in the recognition of the deceased individuals. The forensic odontologist makes use of the knowledge of dentistry in bite mark analysis, fixation of identity in mass disaster, age determination, domestic violence, and child abuse cases. Therefore, the duty and responsibility of forensic odontologist have enhanced in recent times in various medicolegal cases. This article provides an overview of the trends that are evolving in recent times which are used in the field of forensic odontology.

Keywords: Child abuse, domestic violence, forensic dentistry, mass disaster, medicolegal cases¸ bite mark analysis, recent advances

Introduction

Daily we come across violent and heinous activities that shatter the lives of victims, their friends, and families. To preserve the system of law and order, apprehension and subsequent conviction of the criminals is important. In literature, Sherlock Holmes is one of the greatest inspirations for forensic science, particularly for investigating the crime scene which gives few clues that remains as trails of evidence of events. Various forms of trace evidence such as shoe, tire impressions, fingerprints, ballistics, and handwriting of the victim analysis were made use by him for the investigation purpose. Through the discipline of forensic odontology, dentists play a very major role in investigation of crimes. Dentists assist in crime investigation by identifying the victims of crime and disaster through dental records.

In human body, the hardest and most robust tissues are the teeth because of the uniqueness of the teeth to be resistant to decomposition even in accidents, crime scene, after burial, or other severe exposure. Every single individual has a unique dental pattern which is also due to the uniqueness of treatments rendered by the dentist.[1]

The term Forensic is derived from a Latin word "forensic" meaning "before the forum," a place where legal conflicts are debated and discussed. The field of forensic odontology (FO) or forensic dentistry deals with the dental knowledge and their application in various ways for the identification of criminal and prove them in front of civil law that are enforced by police agencies in the system of criminal justice.[2]

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Recent Concepts in Forensic Dental Identification

Facial reconstruction

In forensic science, it plays a very major role due to the fact that in case if the face of the deceased person remains unaltered, the process of identification of the person can be very easily made without any assistance for forensic professionals. In most of the major disaster such as accidents, the body of the deceased person may be decomposed or skeletonized. In such scenarios, the only human part retaining may be the skull and bones. Skulls can remain unchanged for about millions of years and can guide in means of identification. Laser video camera interfaced with a computer or with computed tomography (CT) scanning is used in facial reconstruction. The face can be made with computer software such as Vitrea 2.3 version volumetric

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visualization software. Though the exact image of the face may not be drawn, this method abundantly helps in identification of the individual.

Denture identification methods

Only marked dentures can reveal the exact and positive identity of a person. Denture Labeling is the most easiest and reliable methods of identification. Labelling of dentures approaches are of two categories: Surface labelling and the inclusion method. The surface marking method incorporates scribbling or engraving the denture and marking with embossed letters. Inclusion methods incorporates metal identification bands, computer-printed denture micro-labeling system, denture bar coding, lead paper labeling, embedding the patient photograph, laser etching, T-bar, lenticular card system.[3]

Digital comparison microscopes

In comparison of the samples, the conventional microscope takes more time in adjusting the focus and in aiming different views. Moreover, the observer has to depend on his memory for the comparison of two objects. To avoid this, prototype Virtual Comparison Microscope was developed. This comparison microscope helps in the analysis of the specimens simultaneously. The two microscopes are connected via an optical bridge for a split view window.

Tongue prints

This technique is successful only if antemortem photograph or impression of the tongue is available. The lingual morphological aspects could be preserved by alginate molding technique for the duplication of even the minute details which are different for each and every person. The lingual impression, along with its photographic picture, will constitute a very secure method for forensic dentistry identification. Matching will be compared by combining both the extraction techniques templates.[4]

Role of saliva in forensic odontology

Initial attempts should be performed to collect saliva from bite marks for the purpose of blood group tests. Saliva sample can be combined with forensic DNA analysis in ruling in or ruling out the connection between person and the forensic evidence methylation (which is a chemical change to one of the four building blocks of a person's DNA) changes since our bodies grow older, which contributes to age-related diseases.[3]

Applications of computer-aided design/computer-aided manufacturing in forensic odontology

The rough hand drawn picture from a crime investigation scene which may not be accurate for the identification of exact location of physical evidence, positions of persons, due to lack of proper spatial relationship and three-dimensional (3D) viewing. In real time crime scene Virtual reality or true 3D visualization could be used to investigate the crime scene or to manipulate the scanned body. This gives the overview of the evidence better than standard 3D projections on 2D screens.[5]

Portable dental X-ray generator

NOMADTM one of the portable dental X-ray generators which offers hand-held portability in X-ray technology, offering cordless operation, it has a rechargeable 14.4 V nickel–cadmium battery packs, and provide 100–700 exposures on a single charge. It weighs 8 pounds, has an internal lead shielding and an external lead – acrylic backscatter shield. Automatic shutdown is given to reduce the inadvertent exposure. The NOMADTM can also be used direct current, operated at a fixed 60 kV, 2.3 mA and has a 0.4 mm focal spot with a 20 cm source-to-skin distance. It also meets the radiation safety standards and do not require personal dosimeter. NOMADTM has no risk to the patients as well as the operator and the measured doses are well maintained below recommended levels. The image quality of the X-rays is also exactly same as that of normal X-ray equipment.[5]

Digital photography

In human abuse and bite-mark cases it advantageous to use alternate light imaging photography to document the injuries of the skin that are not evident to the naked eye. Photographs in infrared can be useful in identifying and recording bleeding below the face or for identifying the tattoos detailed in the degrading or the mummified skin. In all the crime cases, the typical visible light photographs are taken by the investigator along special nonvisible spectrum photographic techniques, so that the images are captured with the full spectrum of light.[6]

Digital radiography

Digital radiography uses conventional X-ray source such as 70 KvP X-ray machine capable of 1/100 s exposure which is made up of scintillation screen and a charge-coupled device (CCD) or complementary metal oxide semiconductor (CMOS). When it gets energized by radiation, this device will create a direct image on the pixels of its CCD or CMOS then this radiographic image is sent to a computer through wire or wireless technology. Because of its ability to consume less time, it is recommended useful in clinical and forensic crime cases.[3]

Cone beamed computed tomography

This imaging technique is based on a cone-shaped X-ray beam centered on a 2-D detector which performs one rotation around the object, to produce a series of 2-D images. These images are then rebuilt in 3D by altering the original cone-beam algorithm. Applying these image data to produce a 3D volumetric data set, which is used to provide primary images in 3 orthogonal plans with a back-filtrate projection with sophisticated algorithms (axial, sagittal and coronal). Cone beamed CT are very useful in forensic procedures, offering many advantages for premortem forensic and postmortem forensic imaging which includes better resolution for skeletal imaging, in relatively low cost, which is also portable and simple. It is a noninvasive alternative for age estimation which is an important aspect of forensic dentistry.[7]

Scanning electron microscopy with energy dispersive X-ray spectroscopy and X-ray fluorescence spectrometer

In both scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDS) and X-ray fluorescence spectrometer (XRF), energetic source excites the characteristic X-ray emissions. The sole difference between the techniques is the type of radiation used to excite the emissions. In SEM/EDS, it is an electron beam, but in XRF, an X-ray beam excites the characteristic X-rays. Spectroscopy in both cases helps to measure the energy which is emitted by X-ray peaks, which forms a spectrum that replicates elemental fingerprints of the sample. The ability of XRF is to detect these elements even in very low concentrations. In addition to the dental records, the restorative material brand can also be identified which is an additional variable for the investigator to be more accurate in his conclusion on identification of the victim.[8]

Computer-assisted dental identification software computer-assisted postmortem identification

In mass disaster this program is very useful in assisting forensic odontologists in identifying victims by producing most possible matches. U. S Military on many mass disasters have use CAMPI and also used by forensic odontologists for private sector.[7]

Disaster victim identification system international (disaster victim identification) system

In this system the ante mortem and postmortem pages are displayed simultaneously in the same window of a Microsoft Office Word function, for comparison whereas similarly display of digital photos and radiographs can be done as a part of Microsoft office picture manager function.[5]

WinID

WinID uses an intuitive algorithm that gives the ability to sort for requested identifiers, as well as to compensate and not to eliminate identifiers changes that have occurred due to reasonable and explainable differences in the references.[3]

New trends in DNA analysis

Recent trends and developments are done in four areas of forensic DNA extraction which are analysis of sexual assault evidence which represents a major portion of a forensic DNA laboratory's casework, use of portable rapid DNA instruments which has gained more traction among legal enforcement in recent times, DNA extraction and Chemical biological and radiological (CBR)-contaminated samples which are rare, would be essential in a DNA laboratory's toolbox in the event of an incident, and over viewing DNA extraction altogether.[9]

Smartphone application in facial analysis

Algorithms like color segmentation, template matching etc., are detection for face detection, and Eigen and Fisher face for face recognition. The algorithms have been first made in MATLAB and then implemented on the DROID phone. Applying the algorithms is mostly because of the implementation of the face recognition in a mobile telephone with limited hardware capabilities.[10]

Three dimensional-analysis in bite marks

The issues faced by 2D image capturing system is reduced by 3D image capture and processing system which has simple guidelines to minimize the errors. For example, the MAVIS hardware, can be considered a consistent solution for producing the 3D image of a bite mark for analysis; however, but the MAVIS hardware cannot replicate a satisfactory 3D image of a dental cast.[11]

Stereolithographic printing in forensic odontology

This system of 3D image capture devices minimizes the amount of angular distortion to a greater extent, therefore such this system has a potentiality to create more robust forensic dental evidence which is used in courts and for medicolegal cases. The major application of 3D printing in forensic odontology includes bite mark analysis, 3D-CT facial reconstruction, dental age estimation, sex determination, and physical models.[12]

Automated dental identification system

This technique is solely based on the intensity of the whole region of tooth image and therefore it does not require the presence of sharp boundaries between the teeth. It also provides automated search and matching capabilities for digitized radiographs and photographic dental images and also used in comparison of the teeth which is found in multiple digitized dental records for accessing their similarity.[13]

Artificial intelligence in forensic odontology

FO, which primarily involves teeth and jaws, solely discusses the identity of the individual through the remains. Most of these Artificial Intelligence models are completely based on either artificial neural networks or convolutional neural networks. These models can be promising tools in identifying victims of mass disasters and as a supplemental aid in medicolegal situations.[14]

Laser microetching in metal prothesis for personal identification

The techniques of denture marking are broadly categorized into additive and ablative methods. Additive methods include embedding or impregnation of markers for establishing personal identity. Ablative methods include partial removal of the denture surface which provides a marking for identification. Engraving and etching methods are the most commonly used ablative methods.[15]

Reflected ultraviolet-photograph in forensic odontology

Digital camera that has only been optimized for UV sensitivity and a modified flashlight will be used for capturing the images by the absorbed/reflected UV radiation from various dental products. The initial findings demonstrate the technology's potential in the identification of dental composite materials, the enhancement of dentin-endemic image contrast, the enhancement of enamel violation and helps for potential age estimation.[16]

Virtopsy in forensic odontology

Virtopsy means the combination of two words "virtuals" and "autopsy," which are used to find the reason for death with the help of imaging techniques that are used routinely in clinical medicine like magnetic resonance imaging and computer tomography. Virtopsy incorporates forensic science along with anatomy, roentgenology, computer graphics, biomechanics, and physics. It is quickly gaining importance in the field of forensic. This method has been recently used by forensic odontologists, but yet to make its own mark in this field.[17]

Forensic bio-robots

The quantities and quality which are derived from a DNA is obtained from the EZ1 BioRobot which are comparable with those of the standard protocols which is normally used in laboratory for different forensic relevant biological materials. Soon after the automated DNA extraction the machine saves time, due to the lack of further purification or concentration. It can also be used as an alternative for organic extractions which consumes a lot of time. The advantage of this device is the unstable nature of the chemical regenerations used by the robot.[18]

Digital tooth reconstruction

In case of mass disasters, accidents, and crime investigations, in which human body remains are destroyed or skeletonized, teeth may displace due to postmortem loss or because of improper handling of evidence during the manipulation of skeletal and dental remains. In this situation, forensic tooth reconstruction may be used in the identification process. Forensic tooth reconstruction is the process which aims to reconstruct the morphology of the missing tooth from the skeletal human remains from the intra-alveolar morphology of the dental socket.[19]

Software in forensic odontology

Computer forensics refers to the process of conducting an investigation of the data on a computer by using state of the art techniques to determine whether the evidence exists that aids in internal or legal investigations. In the past few decades, it has been observed that software technology has emerged as an enormous part of forensic odontology. The few software that are used in forensic odontology are DentaScan, Automated dental identification system, Age calculator, Selfie forensic ID, Superimposition software, Auto-computer-aided design, Image T, Adobe photoshop, and Gimp software.[4]

Molecular advancement

AMEL gene

AMEL gene encodes for a highly conservative protein known as "amelogenin." This gene is present on the X and Y chromosomes in human allosomes. The two alleles are similar in exonic sequence, but variant in intronic sequence. Female chromosome consists of two genes (AMEL) that are identical whereas male chromosomes have two genes (AMEL) which are unidentical. Genetic material aids in determining the sex.[20]

Telomere shortening

Age estimation which is based on evidence extracted from the teeth has received subsequent attention in the field of forensic science. The terminal restriction fragment (TRF) length as telomere length is used in age estimation. By using dental pulp DNA, the average TRF length shows a tendency to shortening with aging. Telomere shortening, based on dental pulp DNA is a novel approach to estimate age of the subject at the time of death.[21]

Racemization of aspartic acid

The amount of AAR was determined by using gas chromatography that is parallel to the analysis of pentosidine. Twenty milligrams of dentine was hydrolyzed in 1 ml 6N HCl at 100°C for 6 h and then desiccated overnight in a desiccator. The hydrolysates were esterified with 1 ml isopropanol and 0.1 ml sulfuric acid (97%, w/w) at 110°C for 1 h, then dried by a nitrogen stream and alkalinized with 1 ml 4N ammoniac, extracted with 1 ml dichloromethane, and dried by a nitrogen stream again. The samples were acetylated with 0.05 ml trifluoroacetic anhydride in 1 ml dichloromethane at 60°C for 1 h and desiccated by a nitrogen stream again. After derivatization, amino acids were separated. Then ratio of D-and L-aspartic acid (D/L) are estimated and used for age estimation.[22]

14C levels

This approach determines the amount of carbon 14 isotope in enamel and compares it to recent atmospheric levels. It is used for age estimation.[20]

Circular excision of T-cell receptors

This method is used in detecting the presence of a particular species of DNA present in the blood, mainly circular DNA molecules that are derived from the results of rearrangement of T-lymphocyte DNA. T-lymphocytes carry specific receptors known as T-cell TCR receptors that are used for reorganization of foreign antigens.[23]

Methylation of DNA

This method can be used as a reference in predicting age. DNA methylation is the procedure of addition of methyl groups to DNA; in this process modification of covalent nucleotides in the human genome, like cytosine and guanine, which is a CpG dinucleotide.[24]

Conclusion

FO is a novel branch of dentistry with a immense scope for development. At the crime scene, the forensic odontologists play a significant role in investigating and interpreting the dental evidence. The unique nature of the dental anatomy, morphology and the customized dental restorations done by the dental experts ensures the accuracy when the techniques are appropriately employed. A prominent effort needs to be implemented in order to computerize all the data that are available to facilitate comparison. Both dental professional and dental students must be given proper awareness about

the available and most advanced technologies and its uses in forensic dentistry. Further research has to be encouraged in the discipline of forensic dentistry which will make ways for incorporating latest technologies in establishing human identity.

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Conflicts of interest

There are no conflicts of interest.

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